Modeling Flow Rates and Optimization of Sodium Borohydride and Ethylene Glycol

Brent Vizanko, Chemical Engineering UMTC
Dr. Steven Sternberg, Department of Chemical Engineering UMD

Introduction

In rural areas of Minnesota, traffic signals are currently powered by batteries which are time consuming to keep up and require frequent charging. A novel idea being tested is to replace these batteries with hydrogen fuel cells. These fuel cells need a constant supply of hydrogen gas at a prescribed rate in order to run and provide enough electricity to power the external lights. This hydrogen can be supplied by a tank or it can be created in situ using a chemical reaction. The reaction of sodium borohydride and ethylene glycol is known to produce hydrogen gas which can be harnessed and used to run the fuel cell. The goal of this project was to model the flow of the incoming ethylene glycol and to optimize the reaction described above. The flow rates were modeled using the program LABView and the reaction was optimized by using different concentrations of ethylene glycol/water was used with varying amounts of sodium borohydride.

Model flow rate and test with LABView

↓

Analyze reaction between $NaBH_4$ and ethylene glycol

↓

Test a simple apparatus to run the fuel cell automatically

Using LABView for Flow Modeling

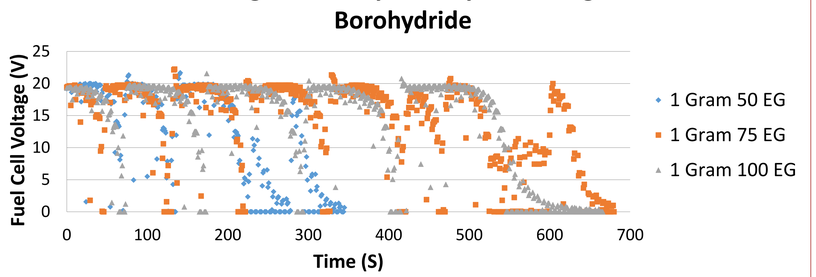
- Three models were derived to describe the flow of water in rubber piping
- One model was empirically derived and two were derived from Bernoulli's equation

Derivative Form $\Delta t = \alpha\left(\frac{V}{\sqrt{\Delta h}}\right)$

Integral Form $t = \frac{A}{aC} * \sqrt{\frac{2}{g}}\left(\sqrt{h_i} - \sqrt{h_f}\right)$

- The best model was found by experiment to be the integrated form of Bernoulli's equation.

Data Obtained From the Fuel Cell



Charts 1-3: Plots showing the time that voltage was produced by the fuel cell indicating the production of hydrogen by the reaction with differeing amounts of sodium borohydride.

Optimizing the Reaction Between $NaBH_4$ and Ethylene Glycol

- In many cases, sodium borohydride is used with diglyme to facilitate the reduction.
- The diglyme complicated the reaction, therefore experiments were run to judge its necessity
- The reaction ran without diglyme deeming it unnecessary to the reaction.
- The voltage produced by the fuel cell was tested with different concentrations of ethylene glycol and water.

Putting it all Together

- A bench test of the system was performed.
- A new VI was written to dispense ethylene glycol automatically and to measure the voltage from the fuel cell.

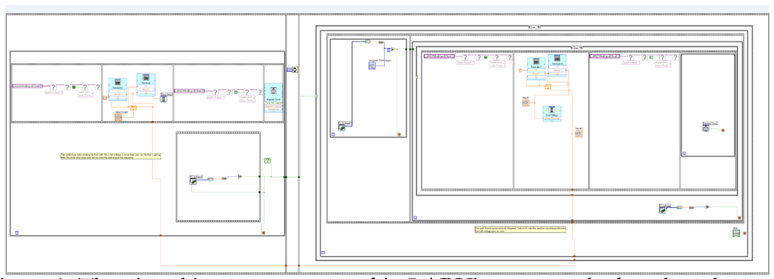


Figure 1: The virtual instrument created in LABView to run the bench scale test of the system.

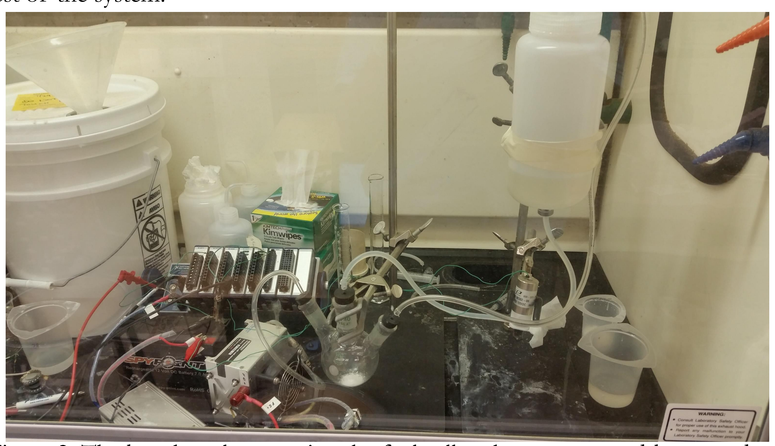


Figure 2: The bench scale test using the fuel cell, a three-way round-bottomed flask, and a bottle containing ethylene glycol.